Proceedings of the Canadian Society for Mechanical Engineering International Congress
32nd Annual Conference of the Computational Fluid Dynamics Society of Canada
Canadian Society of Rheology Symposium
CSME-CFDSC-CSR 2025
May 25–28, 2025, Montréal, Québec, Canada

The Role of Diamide and Glutaraldehyde in Modulating Red Blood Cell Viscosity and Deformability

Tatiana Turcitu[1], Kyle Champagne[1], Andy V. Le[1], Marianne Fenech[1]
[1]Department of mechanical engineering, University of Ottawa, Ottawa, Canada

ABSTRACT

Red blood cell (RBC) deformability is vital for their functionality, enabling them to navigate narrow capillaries, ensure efficient oxygen delivery, and maintain proper blood flow dynamics. Reduced deformability can lead to blockages, impaired oxygen transport, and various vascular complications. Additionally, alterations in RBC deformability are linked to diseases such as sickle cell anemia, hereditary spherocytosis, diabetes, and cardiovascular disorders. *In vitro* studies on RBC deformability often involve modifying RBCs to simulate pathological rigidity, with diamide and glutaraldehyde being the primary agents employed for this purpose. Despite their widespread use, the dose-dependent effects of these agents on RBC mechanics remain incompletely understood.

This study aims to elucidate the effects of different concentrations of diamide (10-200 µM) and different concentrations of glutaraldehyde (0.0001-2%) on RBC viscosity, deformability and morphology at 20% hematocrit (HCT). Viscosity is measured using a viscometer, while deformability is assessed through ektacytometry, a laser diffraction-based technique. Sphericity measurements complement the investigation to provide a comprehensive understanding of the impact of these agents. Results reveal that diamide treatment significantly affects RBC viscosity and sphericity, leading to a progressive increase across all tested concentrations as the concentration of diamide increases. These changes are accompanied by a biphasic response in deformability, as the maximum elongation index (EI_{max}) decreases up to 100 µM before gradually increasing at higher concentrations (120–200 µM). This indicates that diamide induces both morphological and mechanical changes, resulting in heightened RBC rigidity and altered flow properties.

In contrast, glutaraldehyde-treated RBCs display distinct behavior. Viscosity and sphericity remain consistent across all tested concentrations, indicating that glutaraldehyde's effects are predominantly mechanical rather than morphological. However, EI_{max} decreases progressively with increasing glutaraldehyde concentrations, highlighting its impact on RBC deformability. This divergence in response between diamide and glutaraldehyde underscores the importance of understanding the specific mechanisms through which these agents influence RBC properties.

The study addresses a significant knowledge gap in hemorheology by systematically exploring the dose-dependent effects of diamide and glutaraldehyde. These findings contribute to the broader understanding of RBC rigidity and its implications for blood flow and oxygen delivery. Additionally, the insights gained have potential applications in the development of therapeutic strategies for diseases associated with altered RBC deformability. By providing a detailed characterization of these agents, this research advances our knowledge of RBC mechanics and supports further exploration in the fields of hemorheology and microcirculation.